

## Claims

[Claim 1]

A multinuclear rare earth complex characterized in that a plurality of rare earth ions are coordinated  
 5 with one or more types of molecules having a photosensitizing function.

[Claim 2]

The multinuclear rare earth complex according to claim 1, wherein the molecules having a  
 10 photosensitizing function further have a vibrational energy quenching-suppressing function.

[Claim 3]

The multinuclear rare earth complex according to claim 1, which is represented by the general formula:

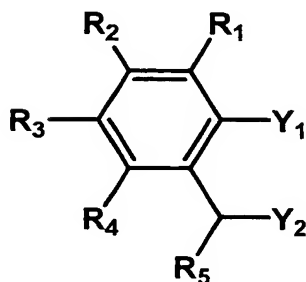
15  $L_p L'_q (Ln)_r X_s,$

wherein

L is a ligand having a photosensitizing function represented by the general formula:

[Chemical Formula 1]

20



wherein R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub> and R<sub>5</sub> are independently  
 hydrogen, a hydroxy group, a substituted or unsubstituted  
 25 amino group, a substituted or unsubstituted aryl group, a  
 nitro group, a cyano group, an alkyl group or a cycloalkyl

group represented by -R, an alkoxy group represented by -OR, or an acyl group represented by -C(C=O)R, where R is a substituted or unsubstituted alkyl group or cycloalkyl group having a carbon number of 1 to 20;

5                   Y<sub>1</sub> is -OH; and

                  Y<sub>2</sub> is =O;

p is an integer of 1 to 40;

L' is a ligand which is a hydroxide ion;

q is an integer of 0 to 8;

10           Ln is a rare earth ion;

r is an integer of 2 to 20, and a plurality of Ln may be the same or different from each other;

X is O, -OH, S, -SH, Se or Te;

s is an integer of 1 to 20, and a plurality of X may be the same or different from each other when s is an integer of 2 to 20; and further, the integers p, r and s have a relationship indicated by the expression:

[Expression 1]

20                    $1 \leq p/r \leq 4, 1 \leq r/s \leq 4$

wherein a manner how Ln is coordinated with L:

Coordination Manner (A) where both Y<sub>1</sub> and Y<sub>2</sub> bind to the identical Ln; Coordination Manner (B) where Y<sub>1</sub> and Y<sub>2</sub> bind to different Ln, respectively; and a combination thereof, wherein when Ln is coordinated with Y<sub>1</sub>, a proton leaves from -OH represented by Y<sub>1</sub> to form -O-, thereby Ln is coordinated with L via -O-.

[Claim 4]

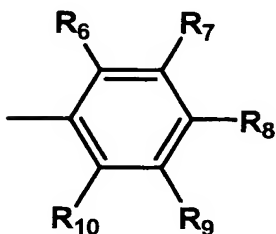
30                   The multinuclear rare earth complex according

to claim 3, wherein at least one of substituents R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub> and R<sub>5</sub> is an alkyl group or a cycloalkyl group represented by -R, an alkoxy group represented by -OR or an acyl group represented by -C(=O)R, where R is a  
 5 substituted or unsubstituted alkyl group or cycloalkyl group having a carbon number of 1 to 20.

[Claim 5]

The multinuclear rare earth complex according to claim 4, wherein R<sub>5</sub> is represented by the formula:

10 [Chemical Formula 2]



wherein R<sub>6</sub>, R<sub>7</sub>, R<sub>8</sub>, R<sub>9</sub> and R<sub>10</sub> are independently hydrogen, a  
 15 hydroxy group, a substituted or unsubstituted amino group, a substituted or unsubstituted aryl group, a nitro group, a cyano group, an alkyl group or a cycloalkyl group represented by -R, an alkoxy group represented by -OR, or an acyl group represented by -C(C=O)R, where R is a  
 20 substituted or unsubstituted alkyl group or cycloalkyl group having a carbon number of 1 to 20, where at least one of R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub>, R<sub>6</sub>, R<sub>7</sub>, R<sub>8</sub>, R<sub>9</sub> and R<sub>10</sub> is an alkyl group or a cycloalkyl group represented by -R, an alkoxy group represented by -OR, or an acyl group represented by  
 25 -C(C=O)R, where R is a substituted or unsubstituted alkyl group or cycloalkyl group having a carbon number of 1 to 20.

[Claim 6]

The multinuclear rare earth complex according to claim 4, wherein  $R_5$  is an alkyl group or a cycloalkyl group represented by -R, an alkoxy group represented by -OR, or an acyl group represented by  $-C(C=O)R$ , where R is a substituted or unsubstituted alkyl group or cycloalkyl group having a carbon number of 1 to 20.

[Claim 7]

The multinuclear rare earth complex according to claim 5 or 6, wherein R is a substituted or unsubstituted alkyl group having a carbon number of 6 to 12.

[Claim 8]

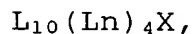
The multinuclear rare earth complex according to claim 7, wherein R is a substituted or unsubstituted alkyl group having a carbon number of 8 to 12.

[Claim 9]

The multinuclear rare earth complex according to claim 1, wherein the rare earth ion is an ion of lanthanide selected from a group consisting of europium (Eu), terbium (Tb), neodymium (Nd), samarium (Sm), erbium (Er) and ytterbium (Yb) or a combination thereof.

[Claim 10]

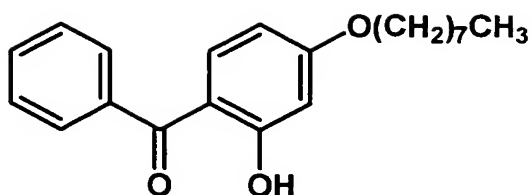
The multinuclear rare earth complex according to claim 5, which is represented by the general formula:



wherein

L is a ligand represented by the formula:

[Chemical Formula 3]



Ln is a europium (Eu) ion; and

X is O, and which has the following properties:

Elementary Analysis: as  $C_{210}H_{250}O_{31}Eu_4$ ,

5 Theoretical values C, 65.04%; H, 6.50%; Eu, 15.67%

Observed values C, 64.90%; H, 6.39%; Eu, 15.41%

IR (KBr,  $cm^{-1}$ ): ( $\nu_{CH}$ )2922, ( $\nu_{C=C}$ )1596, ( $\nu_{Ph-O}$ )1243

$^1H$ -NMR( $CDCl_3$ ):  $\delta$ 12.7(1H,s),  $\delta$ 7.6-7.2(3H,m),  $\delta$ 6.5-6.4(5H,d),  
 $\delta$ 4.0(2H,t),  $\delta$ 1.8(2H,m),  $\delta$ 0.9(3H,t)

10 FAB-MS: m/z 3552.1 [ $Eu_4(L^-)_9O^{2-}$ ] $^+$ .

[Claim 11]

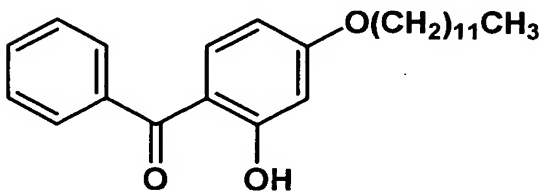
The multinuclear rare earth complex according to claim 5, which is represented by the general formula:

$L_{10}(Ln)_4X$ ,

15 wherein

L is a ligand represented by the formula:

[Chemical Formula 4]



Ln is a europium (Eu) ion; and

20 X is O, and which has the following properties:

Elementary Analysis: as  $C_{250}H_{330}O_{31}Eu_4$ ,

Theoretical values C, 67.64%; H, 7.49%; Eu, 13.69%

Observed values C, 67.50%; H, 7.45%; Eu, 13.49%

IR (KBr,  $\text{cm}^{-1}$ ): ( $\nu_{\text{CH}}$ ) 2924, ( $\nu_{\text{C}=\text{C}}$ ) 1608, ( $\nu_{\text{Ph-O}}$ ) 1247

$^1\text{H-NMR}$  ( $\text{CDCl}_3$ ):  $\delta$  12.7 (1H, s),  $\delta$  7.6–7.3 (3H, m),  $\delta$  6.5–6.4 (5H, d),  
 $\delta$  4.0 (2H, t),  $\delta$  1.8 (2H, m),  $\delta$  0.9 (3H, t)

5 FAB-MS:  $m/z$  4055.9  $[\text{Eu}_4(\text{L}^-)_9\text{O}^{2-}]^+$ .

[Claim 12]

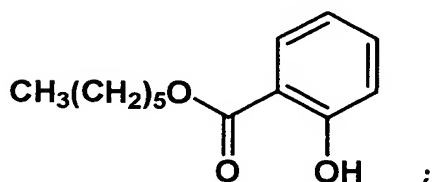
The multinuclear rare earth complex according to claim 6, which is represented by the general formula:

$\text{L}_{16} \text{L}'_8 (\text{Ln})_9 \text{X}_2$ ,

10 wherein

L is a ligand represented by the formula:

[Chemical Formula 5]



L' is  $\text{OH}^-$ ;

15 Ln is a terbium (Tb) ion; and

X is O, and which has the following properties:

Elementary Analysis: as  $\text{C}_{214}\text{H}_{324}\text{O}_{72}\text{NTb}_9$ ,

Theoretical values C, 46.79%; H, 5.93%; Tb, 26.46%

Observed values C, 46.72%; H, 5.18%; Tb, 26.04%

20 IR (KBr,  $\text{cm}^{-1}$ ): ( $\nu_{\text{CH}}$ ) 2957, 2931, ( $\nu_{\text{C}=\text{O}}$ ) 1674, 1637,  
 ( $\nu_{\text{C}=\text{C}}$ ) 1598, ( $\nu_{\text{Ph-O}}$ ) 1243

$^1\text{H-NMR}$  ( $\text{CDCl}_3$ ):  $\delta$  10.9 (1H),  $\delta$  7.9–6.9 (4H),  $\delta$  4.3 (2H),  
 $\delta$  1.8 (2H),  $\delta$  1.4 (6H),  $\delta$  0.9 (3H)

FAB-MS:  $m/z$  5140.2  $[\text{Tb}_9(\text{L}^-)_{16}(\text{O}^{2-})_2(\text{OH}^-)_8+2\text{H}^+]^+$ .

25 [Claim 13]

A fluorescent substance containing the multinuclear rare earth complex according to any one of

claims 1 to 12.

[Claim 14]

A formed resin materials characterized in that  
the fluorescent substance according to claim 13 is  
5 compounded in a plastic polymer.